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A Method For Analyzing Competitive, Dual Source Production Programs

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INTRODUCTION

During the past several years, program managers and cost analysts within the Department of Defense have been asked frequently to consider the cost effectiveness of dual source, competitive procurement strategies. The most common solution to this problem, which we will call the traditional approach, requires difficult assumptions about the behavior of the second source during the competitive program. This paper will present an alternate approach which avoids these difficult assumptions concerning the second source. This alternative approach has been used by the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG) for independent studies of dual sourcing. First, let's look at the traditional approach.

THE TRADITIONAL APPROACH

The traditional analysis of dual source, competitive procurement breaks down the problem into four steps:

- a. Estimate the investment and production costs of the sole source supplier through the remainder of the program.
- b. Estimate the investment required to establish the dual source production capability.

c. Estimate the cost of production by the original source operating in a dual source, competitive environment.

d. Estimate the cost of production by the second competitor.

The most common solution to this problem compares the result of step a. (sole source alternative) with the sum of the results of steps b., c., d. (dual source alternative). The least costly of these alternatives wins.

Difficulties arise in applying the traditional approach because of the assumptions required in step d (estimating the cost of production by the second competitor). This step is much tougher than the other three. One problem is that the identity of the second source is often unknown. Most dual source studies look at the feasibility of dual source before the second source contractor is identified. In this case, data on the second source contractor's capability and experience is unavailable. Another difficulty is forecasting the human and organizational outlook contributing to the second source contractor's behavior. How eager are they? How much of their own money are they willing to invest and risk? Are they willing to reduce their engineering or other staff to reduce costs. These difficulties cause uncertainty in the results of step d. and contribute to errors in the final conclusion drawn from the traditional approach. An approach which circumvents step d. would obviously be most useful.

THE BREAK-EVEN APPROACH

This section will describe the rationale for this approach and the next section will provide a method for implementing it. The break-even approach

develops a structure for deciding if competition is likely to be successful or not without requiring step d. Steps a, b, and c, are calculated and a value for step d at break-even is the result. Here "break-even" means the total cost remaining for the sole source alternative equals the total cost remaining for the dual source alternative. This can be expressed by the following relationship.

$$TC_{SS} + INVESTMENT_{SS} = TC_{C1} + TC_{C2} + INVESTMENT_C \quad (1)$$

Where:

TC_{SS} = Total recurring cost of the sole source supplier after competition begins.

$INVESTMENT_{SS}$ = The remaining investment required to bring the sole source to full production rate capacity.

TC_{C1} = Total recurring cost for Competitor 1. (Prime Source).

TC_{C2} = Total recurring cost for Competitor 2. (New Second Source).

$INVESTMENT_C$ = The investment required to establish the dual source production capability

Because this type of problem is one which requires an initial investment to achieve savings over several years, the break-even calculations should be done on a discounted basis. The specifics will be discussed in a later section.

Using the break-even assumption, relationship (1) becomes an equation. This equation can then be solved for the least understood term, i.e., TC_{c2} , as shown in the following equation.

$$TC_{c2} = TC_{ss} + \text{INVESTMENT}_{ss} - TC_{cl} - \text{INVESTMENT}_c \quad (2)$$

This isolates the most troublesome term as the dependent variable. TC_{c2} represents the maximum recurring cost the government could permit in procuring units from the second source in order to break even. The terms on the right side are portrayed in Figures 1 and 2. Each of the terms on the right side can be calculated and combined to produce a value for TC_{c2} . It's important to note that TC_{c2} represents deduced cost and is not an estimate or forecast of cost.

The next important question is "How Reasonable Is This Deduced Cost?" The best way to answer this question is to compare the deduced cost (TC_{c2}) with the cost from the sole source over the same quantity interval on the cost improvement curve. This is demonstrated in Figure 3. It is important to note the benefit of using the sole source cost experience as a basis for comparison. In most cases, the sole source cost improvement curve is derived from better data (e.g. actual costs) than any other parameter considered.

Another important point is that this comparison should be made for production after the quantity at which the second source is fully tooled and prepared for head-to-head competition. Referring to Figure 3, Q_3 must be after the quantities for the qualification and directed buys have been added. Finally, this comparison should be made over the whole range of Q_3 to Q_4 . The key parameter is calculated in the following expression.

$$Z = 1 - \frac{TC_{C2}}{Base_{SS}} \quad (3)$$

Z can be interpreted as the average percentage difference between the sole source cost experience curve and the deduced cost curve for the second source in a break-even situation. TC_{C2} has been calculated and is portrayed in Figure 3 with an assumed slope for display only. A value for TC_{C2} can be obtained directly from equation (2) without any slope assumption. $Base_{SS}$ is the total cost associated with the area under the sole source cost improvement curve between Q_3 and Q_4 . So Z represents the savings the government will have to get from the second source relative to the sole source experience given the break-even assumption.

Our experience in looking at a half a dozen dual source programs indicates that a value of Z of 25% or less shows that competition is likely to produce enough savings to offset the up-front costs of establishing the dual source capability. Values of Z greater than 25% indicate that competition has only a slight chance of break-even.

IMPLEMENTING THE BREAK-EVEN APPROACH

Implementing the recommended approach requires the resolution of three issues including choosing a year by year quantity split between the competitors, assessing the cost impact of changes in the annual production rate and selecting a point to use as the starting quantity for competitor 2. In the following paragraphs each of the essential remaining assumptions (share, rate effect, and range) is discussed. It is important to remember that the analyst has not had to either directly or indirectly make a point estimate of how much savings will result from competition.

The first fundamental assumption embedded in the analysis is the decision on how to split the annual buys between the competitors. For a starting point the analyst can set the split in quantity at 50:50 once the new source is fully qualified. This choice is made for simplicity. Of course, the share ratio should be set at a different value if there is some indication that one competitor will have a consistent competitive advantage over the other. Whatever method is used, the analyst should test the sensitivity of this assumption by varying the share ratio later in the analysis.

The second basic issue the analyst must address is how to account for the lower production rates resulting from dual source production. While there are many methods available, we have selected an expression which is directly related to the underlying fixed and variable nature of production.

The expression we use is as follows:

$$F_i = \frac{Q_i^{\text{stable}}}{Q_i^{\text{new}}} \times K + (1 - K) \quad (4)$$

Where

i = Annual lot number.

F_i = The rate adjustment factor.

$\frac{Q_i^{\text{stable}}}{Q_i^{\text{new}}}$ = The lot quantity associated with expected stable production rate; this may be the tooled rate for some programs. This parameter may also be different for each of the dual sources.

$\frac{Q_i^{\text{new}}}{Q_i^{\text{stable}}}$ = The lot quantity for the new alternative.

$(1-K)$ = The fixed recurring cost factor or the fraction of the recurring procurement costs which will not change as quantity changes in the short run.

This formula can be directly derived from recognizing that production costs consist of both fixed and variable components and is most applicable for continuous assembly manufacturing processes such as those normally found in major weapon system production facilities. Discussions with various contractors suggest that K (the percent of total recurring costs which are fixed in any year) is in the range .10 to .20. The analyst can, of course, use any other formulation of the rate effect which is appropriate for a specific program. The important point is that some form of appropriate penalty for lower production rates must be included in the analysis.

The third basic assumption is where on the quantity axis of the cost curve to start the second competitor. This is only required for the calculation of Basess later in the evaluation of results and is not an estimate c2 costs. In making this assumption, the analyst must make a judgement based on the circumstances of the program being examined. In some cases, the new competitor may be able to effectively gain the full learning benefits of the original supplier. If there were an effective technology transfer program or a leader/follower contract, the second source competitor might be considered as starting the first production buy at the same quantity as the prime contractor's first production unit (following full scale development). There are also cases where the new competitor will be starting with no production experience on the system and, in this situation, must be assumed to start at unit one of full scale development. The starting point assumption must be based on the conditions present in each specific program being analyzed.

The last point to consider before starting the actual break even calculation is the treatment of system engineering and program management (SE/PM) costs. In doing this analysis it is desirable to treat SE/PM costs separately from hardware production cost. Because SE/PM is a level of effort activity more dependent on program maturity than annual production lot size, it is more accurately treated as a period cost, that is, it is essentially a fixed level of effort independent of the size of the annual procurement. The analyst must also be careful in the treatment of SE/PM costs because of the wide variation among defense contractors in the definition of what is included in this cost category.

BREAK-EVEN EXAMPLE

. Having established a general framework and discussed a number of the key assumptions, the following example demonstrates the implementation. Figure 4 shows an example of a weapon system whose actual recurring development and production costs are shown (the +'s) along with a projection of these points through completion of the procurement program. For this example a nominal production rate of 1000 missiles per year and a fixed recurring cost factor (K) of 15 percent were used. Competition begins with the third production lot, unit 2001 (see Table 1), and the sole source estimate to complete is portrayed by the solid line thereafter. Note that the curve is plotted on a linear-linear graph so that total cost is proportional to area under the curve.

Next the analyst must estimate the net cost of investment required to establish the second source capability, $\text{INVESTMENT}_C - \text{INVESTMENT}_{SS}$ (see Table 2). This estimate should include all costs the Government will incur to implement competition minus any investment costs required to continue with the sole source alternative. These might include:

- costs of new facilities and facility alterations (if they are dedicated to this program);
- cost of general and special tools and test equipment;
- cost of qualification models and qualification testing;
- cost of technology transfer between old and new contractors;
- cost of data, support, schedule impact and administrative effort associated with competition.

In addition to these non-recurring start-up costs, a portion of the cost of any directed (i.e. non-competitive) initial production buys from the new source must be included. Directed buys may occur during the transition period between a sole source situation and the point at which the second source is fully prepared for competitive production. Unit costs during directed buys are greater than costs from a mature production facility because the capability for full production is still being developed. The difference between the cost of these units from the second source and what the same number of units would cost from the sole source is included in the non-recurring category (because they occur during the start-up period).

Next, the analyst needs to estimate a unit cost curve for competitor 1. This contractor usually has an extensive basis for a competitive cost bid due to development and production experience. However, optimism shown in this initial bid may not continue in later bids. Our experience indicates that the curve for competitor 1 is likely to shift downward at the point at which viable competition begins. This shift has ranged from a few percent to fifteen percent of the unit cost at that quantity. In addition, the improvement curve slope may steepen from one to five percent. Our basis for these figures is proprietary data from several programs and so it cannot be quoted here. The choice on a particular program is up to the analyst's judgement and should be based on specific program information (e.g. contractor past experience, competition results in similar systems, contractor eagerness, viability of potential competitors, etc.). An example of a cost improvement curve for Competitor 1 is shown in Figure 4. In this example the curve representing competitor 1 is shifted 10% and rotated 3% from the sole source

curve at the point competition begins. Other combinations of shifts and rotations could produce the same total for competitor 1. The area under the competitor 1 curve provides a number for TC_{C1} in equation (2).

Given the required inputs for equation (2), the deduced break even cost for Competitor 2 can be calculated. This calculation must be performed in present value terms. First, all entries are converted to the present year constant dollars (pure constant dollars with no utility inflation included). Then each year's entry is discounted to present value (DoD accepted practice is 10% per year). Next, equation (2) is evaluated. In our example, TC_{SS} is \$3494M, TC_{C1} is \$1608M, and the net investment is \$254M in present value terms. At this point in the analysis, a solution for TC_{C2} is in hand. In our example, TC_{C2} is \$1632M in present value terms and is displayed in figures 2-4 as the shaded area.

For a comparison with the corresponding portion of the sole source curve, TC_{C2} is converted from present value to constant dollars. This calculation requires the assumption of a slope but is not very sensitive to variations of ± 10 degrees of slope. In most cases the sole source slope can be used.

Referring to Figure 4, consider how to interpret the deduced cost for Competitor 2 (TC_{C2}). Remember, the deduced cost, TC_{C2} , is the maximum cost which can be associated with Competitor 2 and still allow a break-even financially for the government (i.e. pay the bills associated with setting up competition). To determine whether competition is beneficial, decision makers must determine whether the break-even cost associated with Competitor 2 is

achievable. Several criteria are listed below and will be explained using the example.

a. First, how does TC_{C2} compare with $Base_{SS}$? $Base_{SS}$ is the total cost associated with the sole source cost improvement curve over the same quantity range as Competitor 2 (see Figure 3). This portion of the sole source curve reflects the sole source contractor's actual cost experience before competition. This curve provides an important basis for comparison because it involves fewer assumptions than a comparison with the total sole source cost or the total Competitor 1 cost. Equation (3) shows how to express the comparison between TC_{C2} and $Base_{SS}$ in terms of percentage. Our experience indicates a value of 25 percent or less for Z indicate competition is a reasonable alternative. Values greater than 25 percent indicate competition is questionable. Values approaching or exceeding 40 percent indicate competition is an unreasonable approach. The example shows 20% which indicates it will be difficult but achievable to reach a break-even situation.

b. Second, what impact do common vendors have on competition. This factor is critical on some programs. If the sole source prime already has dual qualified vendor sources for some or all of the "buy" portion of unit cost, it is not reasonable to expect the second source (Competitor 2) will obtain significantly better prices from these vendors than the prime source (Competitor 1) has achieved, particularly if the prime has developed vigorous competition among the vendors. As a result, the portion of unit cost associated with those common vendors must be deducted from TC_{SS} and TC_{C1} . This will produce a new solution for TC_{C2} . The comparison discussed in a.

should be recalculated. In the example, 40 percent of the unit cost is common vendors. Figure 5 shows the new result for Z is 28%. This indicates competition is only marginal.

c. Third, the sensitivity of the results can be tested by varying the values specified for key variables and observing the impact on the results. For example, variations could be introduced in the total quantity to be competitively procured, the percent fixed cost in the rate adjustment term, or the investment over the range of any uncertainty, or others. Figure 6 shows the result if the quantity is reduced by 25%. The resulting required shift is 33%. This indicates competition is probably not reasonable for the lower quantity.

CONCLUSION

The OSD CAIG has found the break-even methodology to be useful in assessing the reasonableness of competition alternatives on several major weapon systems. Any attempt to forecast the behavior of prime contractors in competition requires difficult assumptions. We have developed confidence in the approach described in this paper because it avoids the difficult assumptions required in making an explicit estimate of the second source's costs in competition.

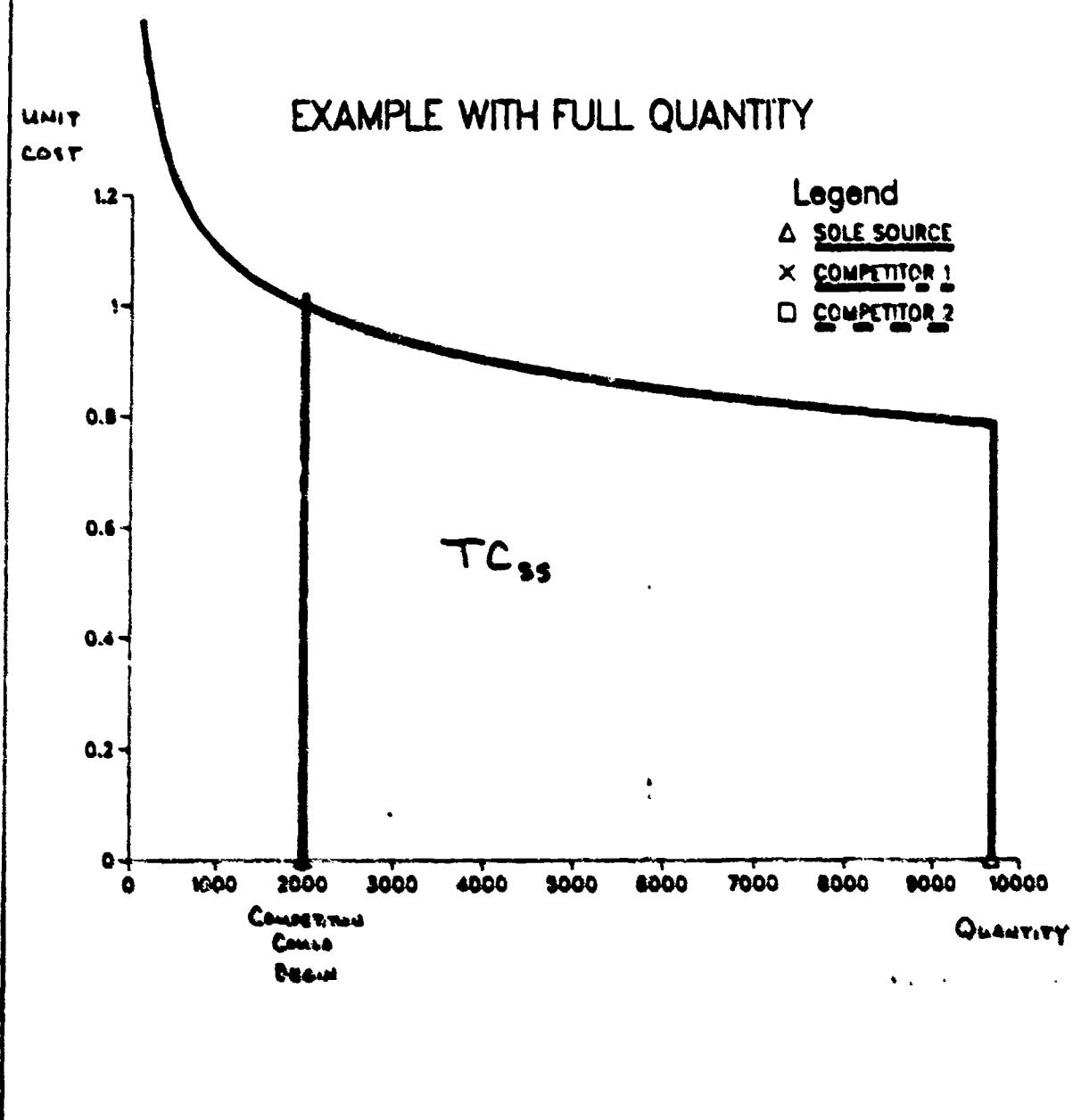


FIGURE 1. SOLE SOURCE COST IMPROVEMENT CURVE AND ITS RELATIONSHIP TO TC_{SS} .

EXAMPLE WITH FULL QUANTITY

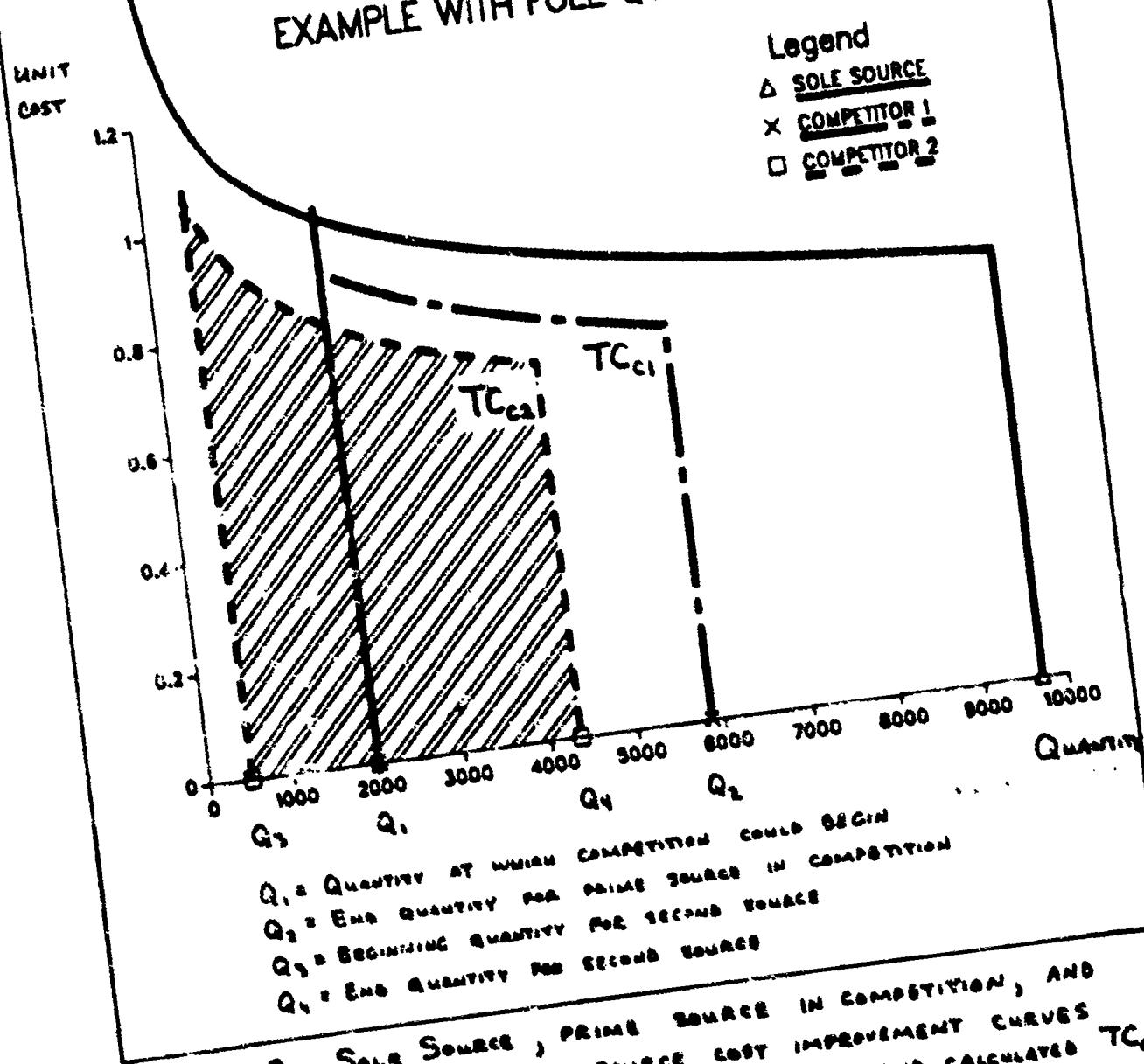


FIGURE 2. SOLE SOURCE, PRIME SOURCE IN COMPETITION, AND TYPICAL SECOND SOURCE COST IMPROVEMENT CURVES AND THEIR RELATIONSHIP TO TC_{C1} AND CALCULATED TC_{C2} .

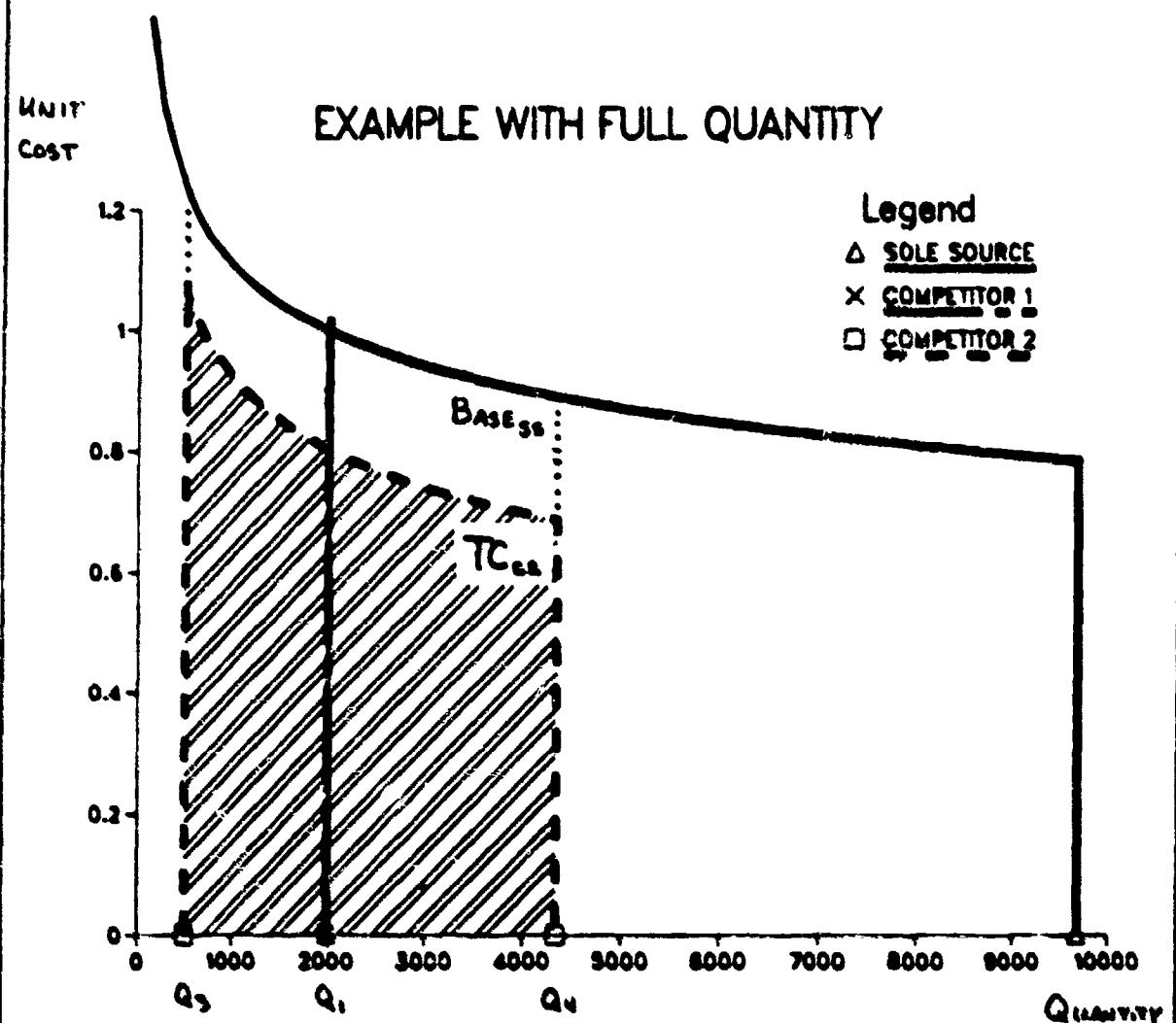


FIGURE 3. DEDUCED OR CALCULATED SECOND SOURCE COSTS (TC_{C_2}) COMPARED WITH SOLE SOURCE COSTS OVER THE SAME QUANTITY INTERVAL.

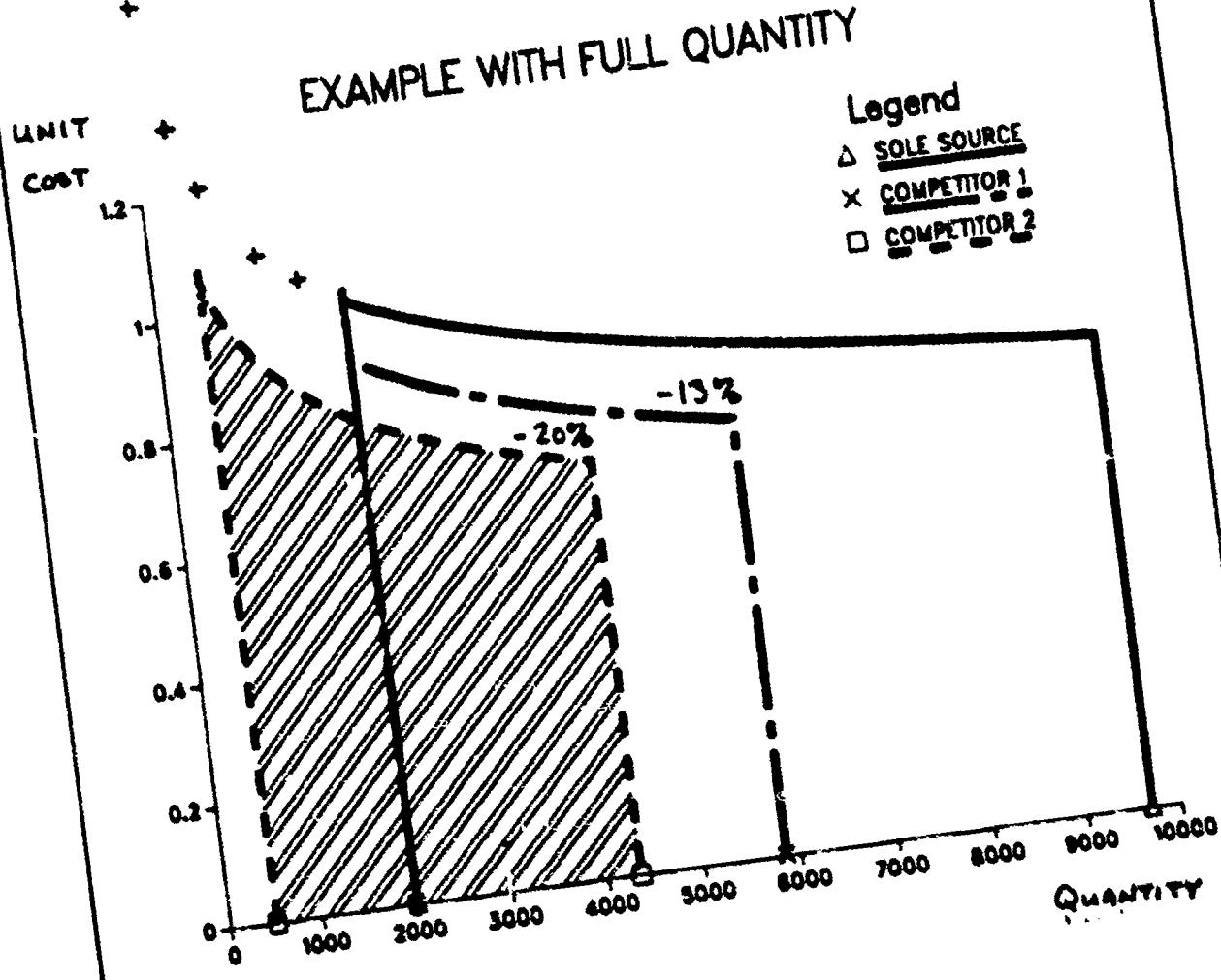


FIGURE 4. EXAMPLE SHOWING AN AVERAGE SHIFT OF 13%
FOR C1 AND A DEDUCED AVERAGE SHIFT
OF 20% FOR C2.

EXAMPLE WITH NO VENDORS

Legend
△ SOLE SOURCE
× COMPETITOR 1
□ COMPETITOR 2

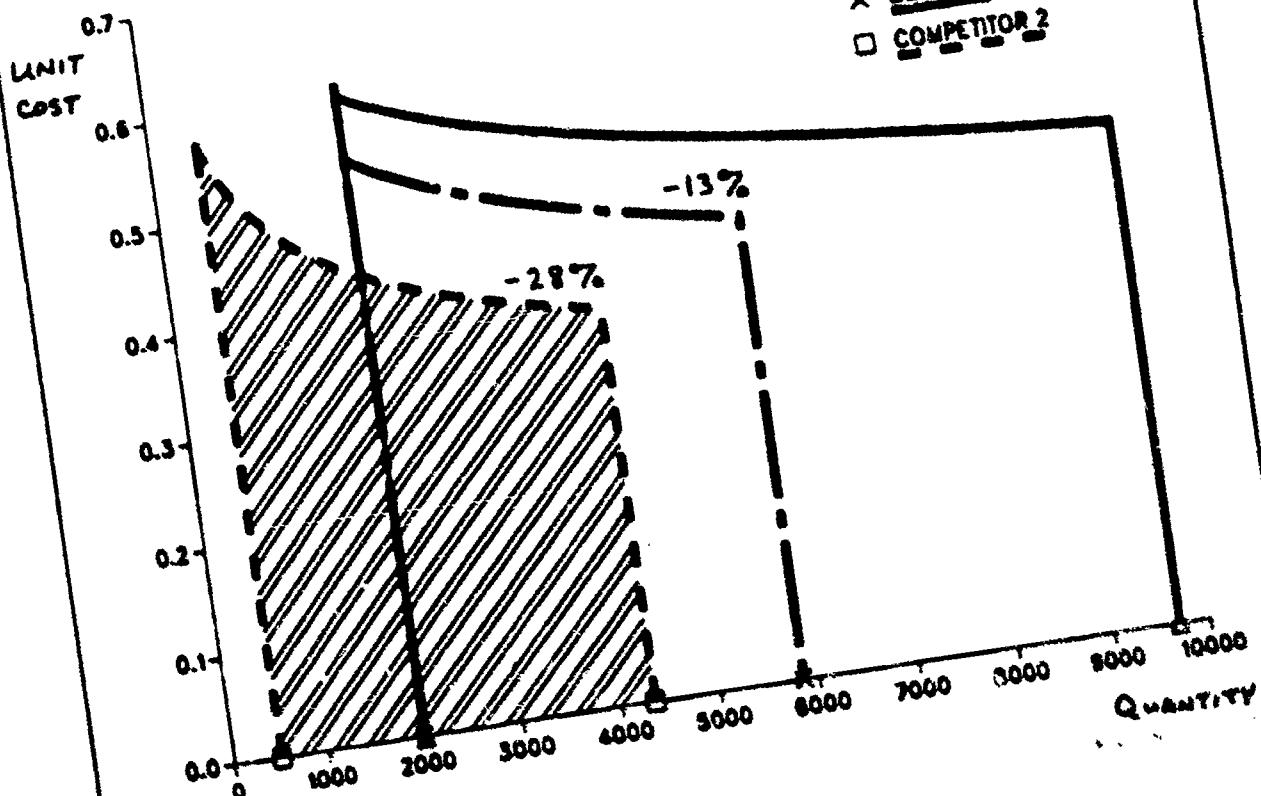


FIGURE 5. EXAMPLE WITH COMMON VENDOR COSTS REMOVED
SHOWING AN AVERAGE SHIFT OF 13% FOR C1
AND A DEDUCED AVERAGE SHIFT OF 28% FOR C2.

EXAMPLE WITH LOWER QUANTITY

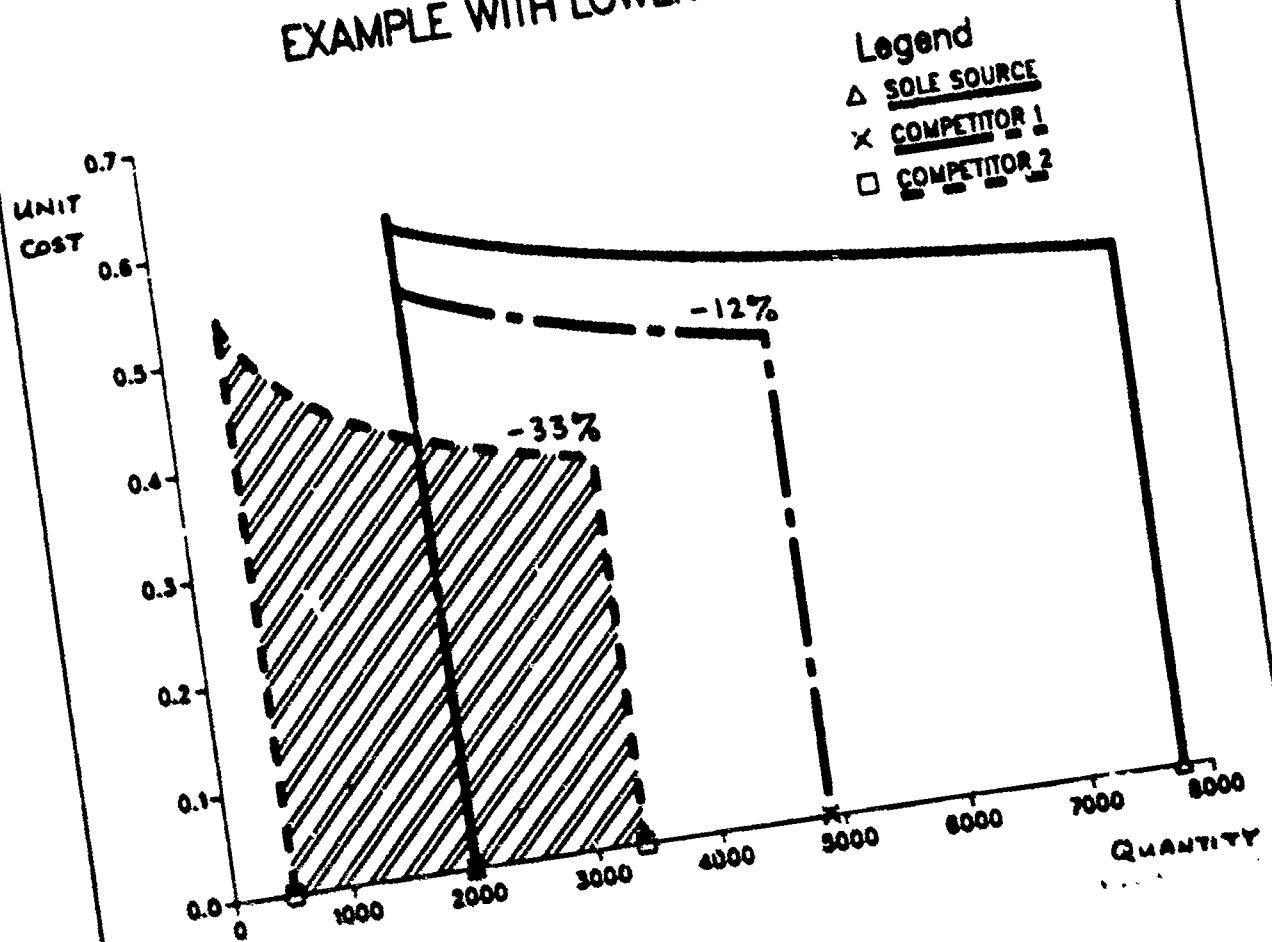


FIGURE 6. EXAMPLE WITH NO VENDORS AND 25% LOWER QUANTITY
SHOWING AN AVERAGE SHIFT OF 12% FOR C1
AND A DECREASED AVERAGE SHIFT OF 33% FOR C2.

TABLE 1
LOT QUANTITIES FOR EXAMPLE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
FSD LOT	1	2	3	4	5	6	7	8	9	10	11	12	13
(IP)	(IP)	(IP)											
SS QUANTITY	200	300	300	500	700	1000	1000	1000	1000	1000	1000	1000	1000
SS CUMULATIVE	200	500	800	1300	2000	3000	4000	5000	6000	7000	8000	9000	10000
C2 LOT	1	2	3	4	5	6	7	8	9	10	11		
(Q)	(DB)	(DB)	(DB)	(DB)	(DB)	(DB)	(DB)	(DB)	(DB)	(DB)	(DB)		
C2 QUANTITY	50	150	300	SPLIT WITH C1	-	-	-	-	-	-	-		
C2 CUMULATIVE	50	200	500	-	-	-	-	-	-	-	-	4500	

FSD = FULL SCALE DEVELOPMENT

IP = INITIAL PRODUCTION

Q = QUALIFICATION BUY

DB = DIRECTED BUY

TABLE 1
LOT QUANTITIES FOR EXAMPLE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
SS LOT	FSD (IP)	1 (IP)	2 (IP)	3 (IP)	4 (IP)	5 (IP)	6 (IP)	7 (IP)	8 (IP)	9 (IP)	10 (IP)	11 (IP)	12 (IP)
SS QUANTITY	200	300	500	700	1000	1000	1000	1000	1000	1000	1000	1000	1000
SS CUMULATIVE	200	500	800	1300	2000	3000	4000	5000	6000	7000	8000	9000	10000
C2 LOT	1 (Q)	2 (DB)	3 (DB)	4 (DB)	5 (DB)	6 (DB)	7 (DB)	8 (DB)	9 (DB)	10 (DB)	11 (DB)		
C2 QUANTITY	50	150	300	SPLIT WITH C1	-	-	-	-	-	-	-		
C2 CUMULATIVE	50	200	500	-	-	-	-	-	-	-	-	4500	

FSD = FULL SCALE DEVELOPMENT

IP = INITIAL PRODUCTION

Q = QUALIFICATION BUY

DB = DIRECTED BUY

TABLE 2
INVESTMENT EXAMPLE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
FACILITIES, TOOLING AND TEST EQUIPMENT	20	40	40	20										120
QUALIFICATION BUY AND TESTING	40	10												50
TECHNOLOGY TRANSFER, SUPPORT, DATA, OTHER	0	10	10	10										40
ADDITIONAL COST OF DIRECTED BUYS (COMPARED WITH SOLE SOURCE)					50	70								120
SUBTOTAL (INVESTMENT _c)														330
INVESTMENT _{ss}														(30)
NET INVESTMENT														300
														—30 90 90 90

TABLE 3
LOT UNIT COSTS FOR EXAMPLE

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
SS LOT	F50	1	2	3	4	5	6	7	8	9	10	11	12
SS QUANTITY	(IP)	(IP)											
SS AVERAGE UNIT COST	1.98	1.35	1.19	1.11	1.03	.97	.92	.88	.86	.84	.82	.80	.79